numeracy in secondary school mathematics

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Context

I teach at Mount Gambier High School, located in a large regional centre (population 24 000). The main industries of the region are forestry, fishing, dairying and agriculture, but there is a growing emphasis on clean energy production (geothermal, wind energy etc). The high school was founded in 1908, and currently has over 1000 students in Years 8 to 12. The size of the school is seen as an advantage in giving it the ability to offer a wide range of subjects and extra-curricular activities and the school has a strong reputation in the local community for providing students with an excellent education. Staff turnover is low, around 101 3% (mainly due to retirements in recent years).

Students mainly come from blue collar families and there is little cultural diversity in the school. Because of the fairly stable regional industry base, many are enrolled in VET courses through the school. (Only about half of Year 12 students are eligible for a Tertiary Entrance Rank.) The University of South Australia has a campus in the city, offering Nursing, Social Work and other programs, but most school leavers who aspire to tertiary education are thought to move to Adelaide and Melbourne for their studies.

The school promotes the Student Voice via the Student Representative Council (SRC) and student input is actively sought in decisions that affect the school. For example, students designed and helped build a courtyard and created sculptures and murals that decorate the grounds. They have a strong sense of ownership of the school and there is little if any vandalism evident. Parents are also very much involved in the school, as many were students here themselves.

Background

I came to the DECS Numeracy in the Learning Areas Project as I started my second year of teaching. I am qualified to teach Mathematics, Chemistry and Junior Science, although I was teaching only Mathematics at the start of the project and took on a Chemistry class later in the year. My project class was a Year 8 Mathematics class, due mainly to the fact that my only junior school classes were Mathematics, and choosing the Year 8s enabled me to work with the same group of students all year. Due to the complexity of the school time-table and curriculum structures, this would not have been possible with a Year 9 class.

School visit: Round 1

Planning and preparation

The initial phase of the project was quite difficult, as it seemed that I was mutating the project a little as I was looking at numeracy across the learning areas but within Mathematics. After the initial project meeting, and still a little unsure of my objectives, I began looking at trying to bring practical and real-life applications more into focus in my Mathematics classes. My initial foray into this was the Clipsal500 Project, which required students to complete a range of tasks using skills with decimals and information from tables of data. The context was the Clipsal500, which is Australia s largest motor sport event and is held annually in Adelaide in March. Most tasks involved the students using decimals in the context of time, to order lap times and determine starting positions, or estimate the time taken to complete the race, given the fastest lap times. Some of these manipulations proved quite difficult for the students; for some students, just locating the relevant data from the large tables of data proved to be a skill that needed practice, while most students found it quite difficult to multiply lap times, as they needed to convert between minutes and seconds as a part of their calculation.

The Clipsal500 Project, which was written in conjunction with another Mathematics teacher, was an idea developed before my involvement in the Numeracy Project. As I reflected on the positive and negative aspects of this first project, I decided that my focus needed to change as part of my preparation for writing the next one. I was still too focussed on the fine, quite technical mechanics of manipulating decimals, rather than the big picture skills. For example, the next time I taught this project, I decided the focus could shift to making reasonable estimates, rather than necessarily carrying out the precise calculations. For some students, the difficulty of the calculations involved decreased their participation in the task.

After discussions with other teachers, led by university researchers, about the importance of numeracy and the numeracy model, I entered into discussions with the Mathematics coordinator about what the next project should be. Discussions began around ensuring that there was a clear context, and that students had the chance to learn some practical skills that they might need later in life. In initial planning sessions this next project took shape as planning an adventure holiday, but as the planning continued, it became The Amazing Race, based, of course, on the television programme in which contestants compete to reach a common destination from a starting point by choosing the best route and means of transport available. Over 4 5 weeks we assembled a booklet for the students which included their itinerary for the two week

race, as well as challenges which were to be completed along the way. Students worked in pairs to book flights and accommodation. They started with a $10 000 budget, as well as having the potential to earn up to $2 000 for successfully completing the three challenges, which included Diving with Sharks in Cairns, Skiing in Switzerland, and visiting The Roman Colosseum. These challenges had a focus on using Directed Number in context, a topic which students had studied in the previous weeks. In the Roman Colosseum challenge students were also required to use formulae in the context of comparing areas of the Colosseum and the Melbourne Cricket Ground, as well as looking at exchange rates and converting between currencies.

Students were introduced to this project about midway through the term and their initial reactions were mixed. Some students seemed quite excited and enthusiastic about the break from normal maths, while others found the magnitude of the project quite intimidating. The project was quite large, but was designed so that there was a lot of scaffolding once students had time to read through the tasks. Students were provided with a list of websites which might assist them to complete the tasks, examples of how they could record their information, and the challenges which they needed to complete. Presenting such a large project to the students was nerve-wracking, as they were not a class that always coped well with activities that were different from normal, and a lot of hours (more than 20) had been invested into developing the tasks.

Lesson observation: The Amazing Race

Having a lesson observed by so many people (the research team) was daunting, so it was good that this task did not require a lot of direct instruction from me, out the front of the class. Instead, the students were mostly able to be self-directed, and begin work immediately upon entering the computer room. Students who were working together would generally log onto two computers, but often they would be found working collaboratively on one machine anyway. Most students made a positive beginning to the task, learning how to search for and book flights and accommodation online. For some, who had never been on a plane before, this was very challenging, and some students needed reassurance that as long as they were not putting their names anywhere, or entering a credit card number, that they were not actually going to book a flight!

Some students became very involved in the race. For example, when I checked where one student was up to he responded I m on my way to Paris! In the initial weeks of the project most students were quite self-motivated and did not require a lot of reminders to stay on task; however, as the project continued, and students encountered a few technical issues with using the computers and Internet, it did become more difficult to keep them focused. While students were working to complete tasks I encouraged them to try to work out how to do things themselves, but I also scaffolded as necessary. Conversations ranged from making sure connecting flights were not departing before the passenger arrived, ways of dealing with different currencies (some students found currency converters online, others converted between Euros and dollars using a conversion rate), using directed numbers in context, how to calculate means, percentages and areas.

Student feedback on The Amazing Race varied, depending on their engagement levels. While some students found the project fun, saying they would rather learn through tasks like this than normal maths, others said they would prefer the normal lesson structure. Due to some network and Internet issues, on some days it took students a very long time to search for their flights

and accommodation, and this created down time for students to be off task. The waiting time allowed students to become bored, and this was reflected in their feedback. Other feedback was more encouraging in identifying the things they had learned, such as how to book flights and find accommodation, make calculations using exchange rates, use percentages, and produce line graphs on the computer.

Upon reflecting on the Amazing Race project once it was finished, I decided that its length needed to be shortened, as the original version took around six weeks in the computer room (originally it was scheduled to take 23 weeks) and a number of students lost interest or became discouraged. A few students seemed almost relieved to return to routine bookwork for a while after this project! Also, students became very focussed on booking the flights and accommodation, and did not necessarily make a good attempt at the (mathematical) challenges which they were required to complete along the way. This meant that they were repeatedly using the same skills, and not broadening their skill base through the challenges. Another tactic that was considered was to break the project up and allocate some time each week towards the project and other lessons to more conventional Mathematical learning.

The next time

While the task booklet for the Amazing Race project did not look a lot different (facts and figures were updated but the majority of the task was very unchanged) the focus was very different this time. Because students had spent so much time booking flights and accommodation in my first attempt at the project, this time I provided them with details of some flights and accommodation at the beginning. This meant that they only had to book a few of these online. This approach did decrease the amount of time that students spent on making bookings, although some groups became a little competitive and looked up their own costs to see if they could find cheaper alternatives.

One big change was the time that students were given to complete the race. Instead of spending a large block of time on the project, students were introduced to it about four weeks into the term, after completing the directed number topic, and given a week to make a start. This allowed students to familiarise themselves with the project and develop some confidence in their ability to complete all the tasks it contained. After this first week, students used a weekly double lesson to continue with the project, while for the remaining 3 lessons of the week the Maths curriculum was learnt in a more traditional manner. This approach proved to have a few positive effects. Firstly, most students looked forward to the double lesson and the opportunity to continue the race and do something a bit different. They did not have as much opportunity to become bored with the project, although there were still a couple students who would have preferred to do normal work in this lesson as well. Mostly the students were able to work independently through the tasks, although sometimes I had to provide a small amount of explicit instruction when it became apparent that most students did not understand or know about a specific concept or skill. For example, I found it necessary to teach skills concerning formulae, timelines (using BC and AD), percentages, and using Excel to produce line graphs. Nevertheless, students were also often able to help each other and pool their knowledge to achieve tasks.

What really improved the effectiveness of the project was the change of focus from booking flights and accommodation, to ensuring that students attempted the challenges. More emphasis was put onto completing these and students knew that they were expected to complete them by certain deadlines. This

resulted in many more successfully completed challenges, a more satisfying experience for high achieving students as well as those who were struggling a little, and more opportunities for all students to demonstrate their learning.

While the Amazing Race is still a large project, interspersing it with lessons where students learned the usual curriculum allowed them to increase their skills in a range of areas through routine classroom activities, while stretching themselves through more challenging tasks. This allowed for a much more balanced range of learning outcomes to be achieved.

School visit: Round 2

Planning and preparation

After the lessons learned in the Amazing Race project I gave a lot of consideration to the types of tasks I wanted to design for the next research cycle. The major problem with the previous project was its length, which required a certain amount of determination (learning stamina!) from the students in order to try and complete it. While its sheer length was discouraging for some students, absences tended to increase the problem because students would use this as an excuse not to complete it. The next planning phase began with this in mind. Discussion centred around the fact that I wanted the next project to be comprised of a series of smaller tasks which would be less daunting to students. Also, if students were absent for an extended period it would be easier to negotiate catch up work or exclude a task if necessary.

I decided I wanted to plan a unit of work based on the topic of Data. I wanted the tasks to have relevance but also an overarching theme to tie them together. I also wanted a clear purpose to the tasks that we were doingt o what I was asking the students to 'find out.' This came from the emphasis in a previous research project meeting on having a critical orientation to the tasks that we are asking students to do. In the ensuing brainstorm it was eventually decided that we would use Approaches to a Healthy Lifestyle as the loose theme for the unit of work. This would require students to collect and use data about themselves and their classmates, as well as finding, interpreting and manipulating data from other sources such as the Australian Bureau of Statistics.

Within the series of eight tasks, students would record the heights of people in their class, calculate the mean and median, summarise the data in frequency tables, construct histograms, and look at the modal class. Students then collected data on their walking speeds by measuring 40m on the running track and timing how long it took them to walk this distance. Using these data, students learned how to calculate their average walking speeds in metres per second, metres per minute and kilometres per hour. They next had to apply this knowledge of their walking speed to the problem of how long it would take them to walk to school. Another task required students to analyse the class height and walking speed data sets to decide whether height was related to walking speed, then use their data to make predictions if possible. This task required students to use Microsoft Excel to represent their data as scatterplots. They had further opportunity to interpret data by looking at statistics on the aging population and childhood obesity.

The teaching style for this unit was completely different from that of the Amazing Race project. I put a lot more focus on explicitly teaching the skills and concepts that students would need for each task, either before starting the task, or during the task at the time students required the knowledge (a just in time approach). This meant I taught students about concepts such as

the mean, median and mode, frequency tables, and various types of graphical representations, produced both by hand and in Excel. Many students had limited knowledge of Excel so it was necessary to spend some time explicitly teaching the skills of graphing in Excel, including such things as adding in titles, labels and changing axes. Some students acquired these skills quickly and easily, while many others needed a lot of support and time to ask questions to learn the basics of graphing in Excel. It was very interesting to watch those students who were positive about learning new skills in using the software, and also those who were wary of the program or even negative about their ability to learn and successfully use the software. When teaching these skills, I felt encouraged when students were comfortable and willing to help those around them and this helped them to sort out any issues more quickly.

The research team observed the task that required students to investigate whether there was any relationship between height and walking speed. Having already done the background work and explicitly taught graphing in Excel, I was pleased to see that students were able to work mostly autonomously in producing their graphs. As the teacher, my role became one of assisting students who needed some support with some of the skills, and, just as importantly, questioning students conclusions. The other interesting aspect of this task was that it used real data, so that the graphs that were obtained were not as idealised and simple as those often found in textbooks. Having graphed the student-collected data before the lesson, I could see that the correlation between height and walking speed was quite low. I was not sure how students would approach this, especially as the data did not really support the predictions of most students.

The graphs that students produced did not all look the same depending on the scale that they used and whether they thought to adjust the axes. Most students were able to describe a general trend in the data, even if the trend was weak, and use this, or other reasoning, to make a prediction about their teacher s and the Principal s walking speeds from their heights. Some of the reasons students used were perhaps not mathematically valid, but it was good to see students trying to give reasons for their predictions. Interestingly, students were focused on their own data point within the scattergram with comments such as This is me (pointing at the appropriate data point) and This is how tall I am and how fast I walk . Using personal data seemed to be effective for engaging students with the task. From a student s perspective, the activity was about them and how they compared to the rest of the class.

Students expressed surprise that the scattergram was not linear, so that taller people did not necessarily walk faster. My role was then to challenge them to explain why this should be the case. Some groups suggested that alternative variablesw ith associated alternative hypothesess hould be explored, including, for example, the relationship between walking speed and leg length or between walking speed and stride rate. One group suggested there might be a stronger relationship between a person s height and their maximum walking pace rather than their natural walking pace.

I was able to use a context that made use of students personal details to introduce the mathematical knowledge that was used in this lesson. The use of personal data encouraged positive dispositions towards involvement in and completion of the task. This task required knowledge of how to produce a scatterplot from a data set using Excel and the capacity to make predictions from trends in the data. Students were asked to use representational tools such as scatterplots and digital tools in the form of computers and Excel. By challenging students to explain the variance in their data from the anticipated linear relationship, it was possible to introduce a critical orientation to the task.

Final reflections

During the course of the project I had the chance to develop and trial new tasks and styles of teaching and learning numeracy. I became increasingly comfortable with using more extended tasks for learning mathematics. However, I believe that it is beneficial if larger projects are made up of self-contained sub-tasks that allow students to move towards smaller, achievable goals. Surveys of students indicated that many of the class appreciated the variety of tasks that they had the opportunity to tackle, and many were quite happy to complete exercises from the textbook interspersed with these other tasks to practise their skills.

While I originally aimed to incorporate two extended units per semester in the future, I have since found that time constraints have made this difficult to do. However, the improved level of engagement that I observe from many students when they are working on thematic activities has seen me try to add to the relevance and real-life applications of all of the mathematics units that I teach. More recently I have worked, in conjunction with a numeracy coach, to find ways to teach introductory algebra and equations so that students can see where they can apply algebra in everyday situations, and hopefully to make it more accessible to all students. Throughout these units there was an increased emphasis in students learning together and being able to verbalise the equations they were working with, and use symbolic representations to write rules for things such as working out the AFL scores for the weekend.

When the project was presented to other staff and governing council, it was positively received, and started discussions among a number of staff around how they are already incorporating numeracy into their learning areas. Ideally it would be good if there could be some coordination between units that students are doing in mathematics and in other subject areas. There are a lot of possibilities to coordinate the themes that students are doing across subjects, but the difficulty is in being able to coordinate this with colleagues, and have the time and opportunity to formally plan these connections across the curriculum.

This process began with a desire to improve my teaching by increasing my focus on embedding student learning in engaging contexts. I believe this is vital in helping students to understand why they need to gain mathematical knowledge. Throughout the course of the project I also had an increased focus on developing activities that provided a critical orientation towards the use of mathematics. It also became obvious how vital the role of positive dispositions is in encouraging students to try approaches to solving a problem for themselves rather than relying on the teacher to provide all the answers. Students need to have the confidence to attempt a problem, even if they are not successful in getting an answer straight away. As part of this, it was important to increase students opportunity to use tools to aid them in the problem-solving process. There was a particular emphasis on digital tools throughout the project as these could assist in analysing data in authentic contexts which could be brought into my classroom.